Enhancing Yield of Tomato (*Lycopersicon esculentum* Mill.) in Sri Lanka Through Organic Fertilizer Solutions

W.M.T.I. Wijesundara
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug1374@sltc.ac.lk

R.M.S.H. Rathnayake
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug1291@sltc.ac.lk

B.M.C.B. Balasooriya
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0199@sltc.ac.lk

M.M.J. Harshana
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0639@sltc.ac.lk

H.G.H. Madusanka
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0874@sltc.ac.lk

J.T.L. Madushanka
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0662@sltc.ac.lk

M.D.D.W. Jayathilaka
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0679@sltc.ac.lk

M.R.C.S.B. Alahakoon
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug1030@sltc.ac.lk

D.D.N. Vibodhani
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
nisansalav@sltc.ac.lk

M.A.U.P. Munasinghe,
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0661@sltc.ac.lk

M.A.P. Madushani,
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0640@sltc.ac.lk

R.M.P.I. Rajapaksha
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
isharar@sltc.ac.lk

H.K.S.P. Bandara
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0685@sltc.ac.lk

B.K.B. Kavinda
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0635@sltc.ac.lk

R.M.S.M.B. Rathnayaka
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
sangeethr@sltc.ac.lk

H.M.V.T. Jayamal
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0652@sltc.ac.lk

W.K.N.H. Wijesekara
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug1294@sltc.ac.lk

I.G.S.H. Bandara
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0077@sltc.ac.lk

K.A.C.G. Kodithuwakku,
Department of Agriculture
SLTC Research University
Padukka, Sri Lanka
21ug0674@sltc.ac.lk

Abstract—**Limited access to chemical fertilizers has led to yield challenges in the cultivation of tomatoes in Sri Lanka, adversely impacting the livelihoods of growers. This experiment was conducted to assess the efficacy of organic fertilizer solutions compared to conventional fertilization methods. The tested fertilizers included chemical fertilizers for nitrogen (N), phosphorus (P), and potassium (K), organic fertilizer solutions, organic fertilizer solutions combined with Albert's solution, and Albert's solution used independently. Two distinct organic fertilizer solutions were formulated and applied during different growth stages of the tomato plant, namely the vegetative and reproductive phases. The first solution consisted of cow dung, *Glyricidia* leaves, and dried banana leaves, and it was administered throughout the vegetative phase. The second solution, designed for the reproductive stage, comprised cow dung, *Glyricidia* leaves, eggshells, and banana peels. Various parameters were measured, including the number of leaves at 12 Weeks After Planting (WAP) (10.27±0.45), root length (35.53±3.22 cm), and fresh fruit weights (41.00 ±2.31 g), which exhibited superior results in comparison to the other treatments. While the total fruit count per plant remained below average in all treatments, the organic fertilizer solutions demonstrated better overall performance, hinting at their potential as commercially available fertilizers. Nonetheless, further investigations are essential to evaluate their ability to enhance tomato fruits' nutritional and flavor attributes.**

Keywords—Sustainable agriculture, yield, organic, improvement, Lycopersicon esculentum mill

I. INTRODUCTION

Tomatoes (*Lycopersicon esculentum* Mill.) are a popular crop grown in both tropical and temperate regions around the world. It belongs to the family Solanaceae and can be recognized as a perennial or semi-perennial. It can be grown in all agroclimatic zones except the Upcountry Wet Zone in Sri Lanka. Currently, tomatoes have a higher demand because the fruits are used in daily life for fresh fruit consumption, and high-value-added vegetable ingredients like tomato sauce, soup, powders, jam, pickles, curries, and salads. Tomatoes are a common crop with numerous health benefits, including anti-cancer properties due to their vitamin C, fiber, and phenolic components [1]. They also positively impact diabetes, immune responses, exercise recovery, and fertility, making them a valuable addition to overall health. However, within the country, there are several issues concerning tomato cultivation, and there are some barriers to keeping up supply related to the demand. One key issue highlighted within this experiment was the poor accessibility to chemical fertilizers. Many farmers use chemical fertilizers to nourish their plants, but this practice raises both economic and environmental concerns. To overcome those problems, shifting to organic fertilizers can be a better solution.

It is considered that organic fertilizers contribute to the higher growth and yield of crops as they contain major nutrients, micronutrients, growth-promoting factors, and beneficial microorganisms that are involved in decomposition. More importantly, organic fertilizers help to reduce the hazards of using excessive amounts of chemical fertilizers. Organic fertilizers take a due season to produce a higher yield relative to chemical fertilizers and this fertilizer application method is more environmentally friendly and economically viable compared to chemical fertilizers [2, 3].

This study was conducted under a circumstance, where the accessibility to chemical fertilizers was insufficient for the usage and due to its expensiveness in the markets in Sri Lanka. Locally available inputs were used to prepare the organic fertilizer and its effects were compared with the current nutrient-supplying practices among farmers.

II. METHODOLOGY

The research was carried out at SLTC Research University, Ingiriya Road, Padukka, Sri Lanka (6.8557° N, 80.0926° E) in a separated open area as a pot cultivation. The experiment was carried out from November 2022 to February 2023. The study was conducted by using two-week-old tomato seedlings (Variety- Thilina) and they were transferred into poly bags in the size of 40 x 40 cm filled with sand and coir dust (1:1). One pot was planted with two seedlings. The experiment was carried out in a Complete Randomized Design (CRD) at a spacing of 50 x 50 cm with five replications per treatment.

In the experiment, two main organic fertilizer solutions were prepared. The first solution was prepared with Cow dung (5 kg), *Gliricidia* leaves (3 kg), and Dried banana leaves (1 kg). These ingredients were chopped well and then mixed with water (40 L) in a large barrel. Then the barrel was closed and allowed to ferment for four weeks before use. In weekly intervals, the solution was agitated to provide aeration. This solution was applied to the tomato plants aiming their vegetative growth until the seventh week of transplanting. The second solution was prepared using Cow dung (7 kg), *Gliricidia* leaves (5 kg), Banana peels (1 kg), and Eggshells (500 g) mixed with water (40 L). The same after-practices were done as the first solution here as well. After the seventh week of transplanting this solution was added to the plants which were previously treated with the solution one. The frequency and the application rates of the treatments are mentioned in Tab. 1. Most importantly, the fruits from plants treated only with chemical fertilizers started to show Blossom End Rot (BER). To avoid that only those replicates were treated with dolomite (40 g/ plant). The fruits affected were not considered for further measurements.

Growth parameters were measured as the Number of leaves per plant and Plant height (cm) at 12 WAP. At the end of the total life span of the plants, they were uprooted, and the root length (cm) was measured. Yield parameters were measured using fresh fruit weight (g), fruit length (cm), and fruit width (cm) of the fruits harvested at the breaker stage. Data were

analyzed using the ANOVA test and the mean separation was done by using Tukey's method. Minitab 19 was used as the statistical software.

III. RESULTS

a. Growth Parameters

According to the current experiment, there was a significant difference among the fertilizer types for the number of leaves 12 WAP. Plants treated with chemical fertilizers had the lowest number of leaves (6.93±0.28) while the other three treatments gave higher results (Tab. 2). From those three treatments, higher results were given with the organic fertilizer mixture (10.27±0.45). However, there were no significant differences among fertilizer types for the plant heights of tomatoes. When it comes to the root length of the plants comparatively a higher root length was given by the plants treated with the organic fertilizer mixture (35.53±3.22 cm) while the lowest length was recorded with the plants treated with the chemical fertilizers (18.96±2.12 cm).

b. Yield Parameters

There were significant differences among the fertilizer types for the fresh weights per fruit in the current experiment. Comparatively, a higher fresh weight was given by the organic fertilizer mixture (41.00±2.31 g) and Albert's solution (38.30±2.43 g) (Tab. 3). The lowest mean fresh weight resulted from the plants treated with chemical fertilizers (29.29±2.48 g). However, there were no significant differences in the fruit length among the tested fertilizer types. Comparatively, a higher fruit width was given by Albert's solution (3.39±0.12 cm) and a lower value was given by the chemical fertilizer (3.01±0.10 cm).

c. Total Number of Fruits Per Plant

The total number of fruits per plant was significantly different among the evaluated fertilizer types (Fig. 1). Comparatively a higher total number of fruits was recorded by the organic fertilizer solution (5.5 ± 0.68) while a lower number was recorded with Albert's solution + organic fertilizer mixture (2.5±0.58).

TABLE I. DETAILS OF EACH TREATMENT AND THEIR APPLICATION RATE

Fertilizer Type	Ingredients and application rates
Chemical Fertilizers (NPK)	Basal fertilizer – 1-2 days before planting (Urea-65, TSP-325, MOP-65 kg/ha) 1st Top dressing - 03 WAP (Urea- 65 kg/ha) 2nd Top dressing - 06 WAP (Urea- 65, MOP- 65 kg/ha)
Organic fertilizer mixture	200 ml per pot in weekly intervals as a soil drench.
Albert's solution + Organic fertilizer mixture	10 g of Albert's mixture was diluted in 4.5 L of water and 200 ml of solution was applied as a foliar spray per pot in weekly intervals. Organic fertilizer mixture was applied 200 ml per pot in weekly intervals.
Albert's solution	10 g of Albert's mixture was diluted in 4.5 L of water and 200 ml of solution was applied as a foliar spray per pot in weekly intervals.

TSP – Triple Super Phosphate, MOP – Muriate of Potash

TABLE II. EFFECT OF DIFFERENT TYPES OF FERTILIZERS ON GROWTH PARAMETERS IN TOMATO

Variable	Number of Leaves	Plant Height (cm)	Root length (cm)
Chemical Fertilizer	6.93 ± 0.28^{b}	81.73 ± 3.19^{a}	18.96 ± 2.12^{c}
Organic fertilizer mixture	10.27 ± 0.45^{a}	88.78 ± 1.76^{a}	35.53 ± 3.22^{a}
Albert's solution + Organic fertilizer mixture	9.37 ± 0.45^{a}	85.75 ± 2.57^{a}	22.47 ± 1.07^{bc}
Albert's solution	9.67 ± 0.67^{a}	88.22 ± 3.36^{a}	31.20 ± 2.44^{ab}

Values in each column represent the means of 5 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$.

TABLE III. EFFECT OF DIFFERENT TYPES OF FERTILIZERS ON YIELD PARAMETERS IN TOMATO

Variable	Fresh Weight (g)	Fruit Length (cm)	Fruit Width (cm)
Chemical Fertilizer	29.29 ± 2.48^{b}	4.29 ± 0.21^{a}	3.01 ± 0.10^{b}
Organic fertilizer mixture	41.00 ± 2.31^{a}	4.84 ± 0.11^{a}	3.29 ± 0.10^{ab}
Albert's solution + Organic fertilizer mixture	36.37 ± 1.82^{ab}	4.73 ± 0.14^{a}	3.22 ± 0.08^{ab}
Albert's solution	38.30 ± 2.43^{a}	4.58 ± 0.17^{a}	3.39 ± 0.12^{a}

Values in each column represent the means of 15 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$

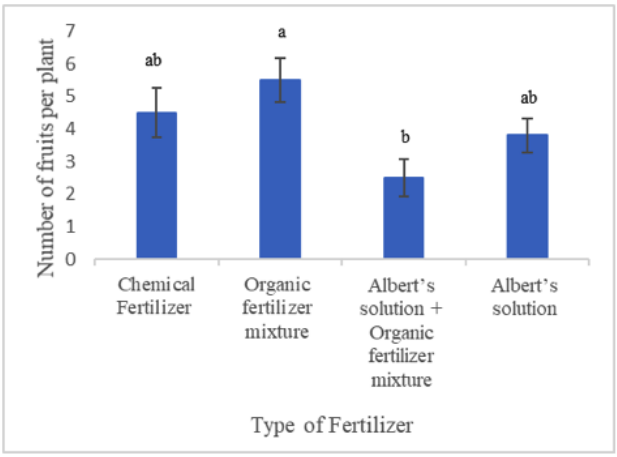

Fig. 1. Effect of different types of fertilizers on the total number of fruits per plant ($p<0.05$)

IV. Discussion

Based on the findings of the current experiment, the organic fertilizer mixture demonstrated superior performance in terms of several key parameters, including the number of leaves at 12 WAP, root length, and fresh fruit weights (Tables II and III). This enhanced performance may be attributed to the synergistic effects of the various components used in formulating the organic fertilizer solutions.

Cow dung, prominent agricultural manure, contains essential elements such as calcium (Ca), magnesium (Mg), sulfur (S), zinc (Zn), boron (B), copper (Cu), manganese (Mn), as well as the primary nutrients N, P, and K. Additionally, it contributes to improved soil structure by enhancing tilth, aeration, water-holding capacity, and fostering the growth of beneficial soil organisms. Cow dung has the potential to positively impact soil properties, including pH, cation exchange capacity, total N, organic carbon, exchangeable magnesium (Mg), and calcium (Ca) [4]. In many tropical and subtropical regions, *Gliricidia sepium* trees, a type of leguminous plant, are employed as living fences. The leaves of *G. sepium* are utilized for green manure and the production of various organic fertilizers due to their high nutritional content. Incorporating *Gliricidia* leaves into this experiment aimed to introduce additional nutrients. Reference [5] reported increased tomato production compared to NPK fertilizer, attributed to the presence of N, Ca, K, and P in *Gliricidia*. They also observed enhanced growth and fruit yield of tomatoes when *Gliricidia* was used as a green manure crop, recommending its use for increased tomato yields [5].

While banana leaves have various agricultural applications, their use as a source of plant nutrition has not been extensively studied. Banana peels, on the other hand, serve as highly effective organic fertilizers. As they decompose, banana peels release nutrients into the soil, including Mg, Ca, P, S, and K. The high K content in banana peels is particularly beneficial for fruit growth. The incorporation of banana peels during the reproductive growth phase of tomato plants likely contributed to the improved fruit characteristics observed (Table III). Eggshells also have potential as a fertilizer due to their Ca content, which is essential for proper tomato fruit development. Both K and Ca play vital roles in supporting healthy tomato fruit growth.

However, neither growth nor yield parameters exhibited significant improvements in plants treated with chemical fertilizers. It is a common observation that chemical fertilizers tend to outperform their organic counterparts [3]. Typically, NPK fertilizer recommendations are prepared for soil cultivation. However, the current experiment employed a soilless medium comprising sand and coir dust. Sand, characterized by its lower cation exchange capacity and reduced organic matter content, has limited nutrient retention capabilities compared to traditional soil. Conversely, the chemical fertilizers utilized in this experiment, while readily available, are more susceptible to nutrient loss from the system if they fail to adhere to the growing medium effectively. In contrast, the organic fertilizer solution featured a higher organic matter content, which facilitated nutrient adherence to the growing medium. Notably, the prevailing adverse weather conditions, including heavy rainfall, may have exacerbated the situation when chemical fertilizers were used, leading to nutrient loss through leaching, particularly with respect to N.

In comparison to previous studies [6], the current results revealed significantly lower fruit yields across all treatment groups (Fig. 1). It is essential to acknowledge that adverse weather conditions and the characteristics of the growth medium likely had detrimental effects on all treatments, irrespective of treatment effect. To further improve the current experiment, it is proposed to conduct it under controlled greenhouse conditions, employing the same growth medium. Additionally, performing the experiment as a plot trial in an open-field setting is recommended. These approaches will enable a more comprehensive investigation to determine the specific conditions under which organic fertilizer treatments can yield superior results. Such a comparative study will provide valuable insights into optimizing organic fertilizer applications for improved crop yields.

V. Conclusion

The current experiment was carried out in a setting where farmers lacked access to affordable chemical fertilizers. The major goal was to contrast the results of using various organic fertilizer sources as combined solutions with the way tomatoes are currently fertilized. The results of this experiment showed that when tomatoes are grown in pots with the use of sand and coir dust in open field circumstances, the use of organic

fertilizer combinations can increase the output of tomatoes compared to standard fertilizing procedures. To achieve better outcomes, the solution's formula must be altered in accordance with the plant's developmental stage. To attain the potential yield, the impact of the environment must be adequately managed in the interim.

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